Original Article

Effect of implementation of Enhanced Recovery After Surgery Protocol on elective open simple nephrectomy in urolithiasis

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Abstract

Objective: To assess the impact of the implementation of an Enhanced Recovery After Surgery (ERAS) protocol in elective open simple nephrectomy in urolithiasis patients.

Materials and Methods: Data from 43 patients were collated. Sixteen were in the ERAS group and 27 in the pre-ERAS group, the division created by date of the procedure. The ERAS protocol included preoperative education, standardized perioperative care, early mobilization, and postoperative pain management. Outcomes, including length of hospital stay (LOS), first flatus, first defecation, complications, pain scores, creatinine level (Cr), glomerular filtration rate (GFR) and associated costs, were compared.

Results: The ERAS group exhibited significantly lower total LOS (3.19±0.40 days vs. 6.22±1.55 days, $p < 0.001$), earlier first flatus (1.19±0.40 days vs. 2.66±1.11 days, $p < 0.001$), first defecation (1.56±0.73 days vs. 3.11±1.28 days, $p < 0.001$), and lower postoperative ileus rates (12.5% vs. 71.43%, $p = 0.01$) than the control group. Lower pain scores at 1, 6, 24, and 48 hours post-surgery ($p < 0.05$) were also recorded in comparison to the control group. No significant differences in Cr and GFR were observed ($p > 0.05$). Although ERAS treatment costs were marginally lower, the difference was not statistically significant (23,833±3731.48 Baht vs. 23,930±3068.45 Baht, $p = 0.927$).

Conclusion: ERAS implementation in elective open simple nephrectomy for urolithiasis reduces LOS, and postoperative pain, accelerates recovery of bowel function, and allows quicker resumption of normal activities. These benefits come without increased risk of readmission or complications, and without compromising postoperative renal function. All these advantages may also result in cost savings.

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Introduction

Urolithiasis represents a significant healthcare burden worldwide. There are multiple approaches to the treatment of urolithiasis. One such approach is nephrectomy, which is indicated in patients with recurrent urinary tract infection, pain, severe hydronephrosis, pyonephrosis and fistula formation.[1]

Enhanced Recovery after Surgery (ERAS) is a modern and evidence-based approach in the field of medicine that aims to improve patient outcome. Studies in ERAS have shown a decrease in complications and hospital stays, improvements in cardiopulmonary function, earlier return of bowel function, and faster resumption of normal activities. However, it does not lead to a reduction in mortality or readmission.[2-5]

ERAS was initially introduced by Professor Kehlet and was successfully implemented in colorectal surgery for the first time in 1997.[6,7] An ERAS protocol, or fast-track surgery, can be implemented using a multidisciplinary and multimodal approach to reduce perioperative and intraoperative stress responses and promote the recovery of the function of various organs following surgery.[8]

Currently, the ERAS approach is being applied in association with various surgical procedures including colonic surgery[9], vascular surgery[10], thoracic surgery[11], and urological surgery.[12-16] The ERAS approach has been implemented in various aspects of urological surgery including laparoscopic radical nephrectomy[12], partial nephrectomy[13], radical cystectomy[14], laparoscopic radical prostatectomy[15], and adrenalectomy.[16] However, there is limited research on the successful application of ERAS in nephrectomy procedures for patients with urolithiasis.

This research aims to investigate the impact of an ERAS protocol on elective open simple nephrectomy for urolithiasis.

Materials and Methods

Patients

This research is a retro to prospective cohort study, meaning specifically that the data collection is divided into two periods: the retrospective analysis of urolithiasis patients who underwent elective nephrectomy at Loei Hospital from February 2017 to June 2020 (Pre-ERAS group) and the prospective study of urolithiasis patients who underwent elective nephrectomy at Loei Hospital from July 2020 to November 2023 (ERAS group). A total of 43 urolithiasis patients were included in the study, with 16 in the ERAS group and 27 in the Pre-ERAS group. Inclusion criteria were individuals with severe kidney impairment due to urolithiasis, those within the age range 18 to 80 years and who met the specific indications to undergo open simple nephrectomy as elective cases. Exclusion criteria included cases where adjacent organ injury was discovered during surgery and also cases with excessive bleeding leading to unstable vital signs. This study received approval from the Ethics Committee of Loei Hospital (approval number: EC023/2564).

Open simple nephrectomy

All patients underwent open simple nephrectomy using the retroperitoneal approach, with a single surgeon carrying out all the cases. For each patient, the anesthesiologist's approach involved a thorough assessment of the suitability of the patient for the preferred method of anesthesia. The primary choice was a combination of general anesthesia and epidural block. However, if an epidural block was found to be unsuitable for a patient, the anesthesiologist opted for general anesthesia and coordinated with the surgeon to enable local infiltration of 0.25% Marcaine around the surgical wound at the end of surgery. Following general anesthesia, the patient was positioned in the flank position, and after administration of antibiotic prophylaxis, the flank wall was meticulously opened layer by layer. Dissection around the kidney was completed, allowing the renal artery and vein to be exposed. The ureter was identified. Following complete separation, the kidney was then removed, and placement of a retroperitoneal drain was considered.

Pre-ERAS management

The patients in this study received traditional preoperative management, which included a 12-hour preoperative fasting period, bowel preparation before surgery, and restriction from food and fluids immediately post-surgery. Bed rest was obligatory for the first 24 hours, and then there was a gradual transition to a liquid diet and then a soft diet, along with the initiation of ambulation. Pain control involved administration of pain-relief medication when patients experienced significant

discomfort and requested it. Urinary catheters were removed on postoperative day (POD) 2 or 3, or later if patients demonstrated good ambulation. The drainage tube was removed when the volume of drainage decreased to less than 50 ml over three consecutive days.

ERAS management

Patients undergoing ERAS management received guidance and had their questions addressed by nurses and physicians regarding the rationale and practices associated with the ERAS protocol. This approach aims to reduce anxiety and uncertainties. Specifically, patients undergo a 6-9 hour preoperative fasting period, with no bowel preparation required. After surgery, if the patient awakens well, they start a soft diet and ambulation is initiated within 24 hours. Pain management involves administration of epidural analgesia or infiltration of the incision with local anesthetic (in cases where intraoperative epidural anesthesia is not performed) as needed when patients experience significant pain and request it. Removal of urinary catheters is planned on POD 1, while drainage tubes will be removed on POD 2 in cases where intraoperative drains are used and when the drainage volume falls below 50 ml for one day.

Data collection, definitions, and primary outcomes

General data collection included gender, age, BMI, and any underlying medical conditions. Stone-related data included any details about the location of the stone, the history of stone treatment, the causes of obstruction, and pathological findings.

Surgical data covered the method of anesthesia used, the duration of surgery, estimated blood loss during the procedure, the use of drainage tubes, and any intraoperative findings of abscesses in the kidney.

The outcome data included the length of hospital stay (LOS), comprising both total LOS and postoperative LOS., the first date of ambulation, the first instance of passing gas (first flatus), the commencement of bowel movements (first defecation), and the removal dates of urinary catheters and drainage tubes. Data were collected up to 2 weeks post-surgery and reported using the Clavien-Dindo classification system.

Renal function, both preoperative and postoperative, was evaluated by measuring creatinine (Cr) levels and estimating the glomerular filtration rate (GFR) using the MDRD GFR equation. Assessments were conducted on the date of admission and on POD 1.

Pain scores were recorded using the Visual Analog Scale (VAS) at 1, 6, 24, and 48 hours post-surgery, as assessed by nursing staff.

Lastly, total cost data was calculated covering pertinent expenses, including laboratory tests, imaging studies, medication, surgical costs, and service charges.

Statistical analysis

For the statistical analysis, STATA version 14 was used to analyze categorical data, such as gender and comorbidities, using counts and percentages. Group differences were compared using statistical tests, including Fisher's exact test. Continuous data, including age, BMI, operative time, and estimated blood loss were analyzed using mean values and standard deviation. Group differences in normally distributed data were analyzed using Independent t-tests, while skewed continuous data were assessed using the Mann-Whitney U test. A probability of $p < 0.05$ was used to indicate a statistically significant difference.

Pain score parameters, including basal condition pain scores and those measured at 1, 6, 24, and 48 hours postoperative, were analyzed using Repeated Measured Analysis of Variance tests to assess differences between the ERAS and Non-ERAS groups. Pairwise post hoc tests were conducted to compare differences in pain score parameters between each group. A p-value < 0.05 was considered statistically significant.

Results

Clinical features and surgical overview of participants

Forty-three patients with urolithiasis who underwent elective open simple nephrectomy for urolithiasis were enrolled onto this study, with 27 cases in the Pre-ERAS group and 16 cases in the ERAS group. The demographic data of the two groups is shown in Table 2. The findings revealed no statistically significant differences between the groups regarding demographic data including gender, age, body mass index (BMI), side, under-

Table 1. The key differences between the Pre-ERAS and ERAS protocols are as follows in patients undergoing open simple nephrectomy

Perioperative management	Pre-ERAS group	ERAS group
1. Patient education	Routine description of medical procedures	Routine description of medical procedures and explanation of the ERAS program. Promotion of its utilization is an essential component of this program
2. Preoperative fasting	Preoperative fasting starting 12 hr before surgery	Preoperative fasting starting 6-9 hr before surgery
3. Bowel preparation	Preparation of bowel using soap and water	No bowel preparation
4. General anesthesia plan	Balanced anesthesia	Balanced anesthesia in conjunction with the consideration of using epidural analgesia
5. Standard anesthesia	Intraoperative intravenous opioids are utilized for pain	Utilization of short-acting opioids, prevention of hypoxemia and hypothermia, maintaining control over intraoperative blood glucose and blood pressure, timely administration of blood products
6. Postoperative pain control	Intraoperative: intravenous injection of fentanyl/pethidine Postoperative: intravenous injection of morphine	Intraoperative: epidural nerve block or incisional infiltration, intravenous injection of fentanyl/pethidine Postoperative: epidural nerve block or incisional infiltration, intravenous injection of morphine
7. Ileus prevention	No	Gum chewing, early ambulation, bisacodyl rectal suppository, and minimal opioid usage
8. Postoperative activities	Commencement of ambulation based on the patient's individual capability to do so	Encouraging patient mobilization, starting from sitting and standing, gradually progressing to walking, once the patient begins to wake
9. Urinary catheter removal	POD 2-3	POD 1
10. Drainage tube removal	POD 4-5	If a drainage tube is inserted, it will be removed on POD 2
11. Postoperative fluid infusion	Patients receive 2,500 to 3,000 ml of fluids daily for 3 to 4 days after surgery	Controlled infusion with removal on POD1
12. Postoperative eating	Provision of fluids and food on POD 1 or until there are signs of bowel movement	Initiation of a soft diet when the patient is awake and alert

ERAS = enhanced recovery after surgery, POD = postoperative day

lying disease, history of previous surgery (ureterorenoscopy, open surgery urolithiasis), cause of obstruction, and pathological findings.

Analgesia during surgery differed between the Pre-ERAS and ERAS groups. In the Pre-ERAS group, the sole analgesic procedure used was general anesthesia, while in the ERAS group, 12 patients (75%) received general anesthesia in combination with epidural analgesia, and 4 patients (25%) received general anesthesia in combination with local analgesia. In terms of intraoperative findings (including surgical duration and estimated blood loss), there were no statistically significant differences between the two groups. Prophylactic drainage was utilized in all cases within the Pre-ERAS group, while in the ERAS group drainage was only used in 2 cases.

Comparison of renal function parameters

When comparing the preoperative and postoperative Cr and GFR values between the pre-ERAS and ERAS groups, no statistically

Table 2. Demographic data and surgical overview of participants

Variables	Pre-ERAS (n=27)		ERAS (n=16)		P-value
	n	%	n	%	
Sex					1.000[a]
Male	17	62.96	10	62.50	
Female	10	37.04	6	37.50	
Age (year) mean±SD	57.26	±10.42	58.63	±14.08	0.718[b]
<60 year	16	59.26	6	37.50	0.215[a]
>60 year	11	40.74	10	62.50	
BMI (kg/m^2) mean±SD	22.97	±4.17	21.49	±4.57	0.283[c]
Side					0.526[a]
Right	17	62.96	8	50.00	
Left	10	37.04	8	50.00	
Underlying diseases					
No	13	48.15	4	25.00	0.199[a]
Yes	14	51.85	12	75.00	
Diabetes mellitus	6	42.86	4	33.33	0.781[a]
Hypertension	10	71.43	7	58.33	0.683[a]
Dyslipidemia	4	28.57	1	8.33	0.330[a]
Chronic kidney disease*	6	42.86	5	41.67	1.000[a]
Chronic obstructive pulmonary disease	1	7.14	0	0.00	1.000[a]
Gouty arthritis	1	7.14	0	0.00	1.000[a]
Previous ureterorenoscopy	0	0.00	2	12.50	0.133[a]
Previous open surgery	2	7.41	3	18.75	0.344[a]
Causes of obstruction					
Ureteric calculi	15	55.56	6	37.50	0.347[a]
Staghorn stone	9	33.33	7	43.75	0.530[a]
Renal pelvis stone	3	11.11	1	6.25	1.000[a]
Caliceal stone	0	0.00	2	12.50	0.133[a]
Pathology					
Chronic pyelonephritis	24	88.89	14	87.50	1.000[a]
Xanthogranulomatous pyelonephritis	0	0.00	2	12.50	0.133[a]
Squamous metaplasia	1	3.70	0	0.00	1.000[a]
Urothelial cancer	1	3.70	0	0.00	1.000[a]
Caseous granulomatous pyelonephritis	1	3.70	0	0.00	1.000[a]
Anesthesia					
General anesthesia	27	100.00	0	0.00	<0.001[a]
General anesthesia with epidural analgesia	0	0.00	12	75.00	<0.001[a]
General anesthesia with local analgesia	0	0.00	4	25.00	0.015[a]
Operative time (minutes) mean±SD	105.93	±31.16	129.38	±51.15	0.068[b]
Intraoperative blood loss (ml) mean±SD	261.48	±323.20	343.75	±510.19	0.520[b]
Intraoperative pus present	6	22.22	5	31.25	0.719[a]
Prophylactic drainage	27	100.00	2	12.5	<0.001[a]

Statistical analysis was conducted using various tests: [a]Fisher's exact, [b]Independent t-test, [c]Mann-Whitney U test
*Chronic kidney disease is defined by a glomerular filtration rate less than 60 ml/min/1.73 m^2 for at least 3 months.[17]
SD = standard deviation, ERAS = Enhanced Recovery After Surgery, BMI = body mass index

significant differences were found as shown in Table 3.

Postoperative outcomes and complications

The study findings showed that patients in the ERAS group had a statistically significant shorter Total LOS and postoperative LOS in

Table 3. Comparison of renal function parameters

Variables	Pre-ERAS (n=27)		ERAS (n=16)		P-value
	Mean	±SD	Mean	±SD	
Cr level					
Preoperative Cr (mg/dl)	1.12	0.41	1.21	0.54	0.541[b]
Postoperative Cr (mg/dl)	1.11	0.42	1.31	0.63	0.231[b]
GFR level					
Preoperative GFR (ml/minute/1.73 m^2)	72.72	23.17	70.23	27.50	0.752[b]
Postoperative GFR (ml/minute/1.73 m^2)	72.90	22.79	65.77	29.54	0.381[b]

[b]Independent t-test
ERAS = Enhanced Recovery After Surgery, SD = standard deviation, Cr = creatinine, GFR = glomerular filtration rate

Table 4. Comparison of outcome

Variables	Pre-ERAS (n=27)		ERAS (n=16)		P-value
	Mean	±SD	Mean	±SD	
Total LOS (day)	6.22	1.55	3.19	0.40	< 0.001[c]
Postoperative LOS (day)	5.22	1.55	2.19	0.40	< 0.001[c]
Ambulation (day)	1.59	0.64	1.13	0.34	0.010[c]
First flatus (day)	2.66	1.11	1.19	0.40	< 0.001[c]
First defecation (day)	3.11	1.28	1.56	0.73	< 0.001[c]
Foley catheter removal (day)	2.93	1.44	1.25	0.45	0.001[b]
drainage tube removal (day)	4.70	0.67	0.25	0.68	< 0.001[b]
Cost (bath)	23,930	3068.45	23,833	3731.48	0.927[c]

Statistical analysis was conducted using various tests: [b]Independent t-test, [c]Mann-Whitney U test
ERAS = Enhanced Recovery After Surgery, SD = standard deviation, LOS = length of stay

comparison to the pre-ERAS group. Additionally, statistically significant faster ambulation, and time to first flatus, and first defecation were observed in the ERAS group when compared to the pre-ERAS group.

Regarding Foley catheter removal, it was found that the ERAS group had a statistically significant shorter duration of Foley catheterization compared to the pre-ERAS group.

In this study, two patients in the ERAS group required the placement of drainage tubes, and when compared to the pre-ERAS group, it was found that the duration of drainage tube placement was statistically significantly shorter (Table 4).

With regard to complications, in both groups only grade 1-2 complications occurred following Elective Nephrectomy, and there was no statistically significant difference in the incidence of complications between the two groups. It was observed that the incidence of ileus was statistically significantly lower in the ERAS group than in the Pre-ERAS group. However, urinary retention occurred in 2 patients in the ERAS group, while it was not observed in the Pre-ERAS group. With regard to readmissions, one case was recorded in the Pre-ERAS group, while there were no readmissions in the ERAS group (Table 5).

Pain control

It was observed in the study that the ERAS group had significantly lower pain scores at 1, 6, 24 and 48 hours in comparison to the Pre-ERAS group (Table 6).

Table 5. Comparison of complications

Variables	Pre-ERAS (n=27)		ERAS (n=16)		P-value
	Mean	±SD	Mean	±SD	
Complications					
No	7	25.93	8	50.00	0.185[a]
Yes	20	74.07	8	50.00	
Grade					
Grade 1	11	55.00	4	50.00	1.000[a]
Grade 2	9	45.00	4	50.00	
Hypotension and bradycardia	0	0.00	1	12.50	0.286[a]
Acute urinary retention	0	0.00	2	25.00	0.074[a]
Ileus	15	71.43	1	12.50	0.010[a]
Fever	6	30.00	2	25.00	1.000[a]
Attack of gout	1	5.00	0	0.00	1.000[a]
Drug allergy	1	5.00	0	0.00	1.000[a]
Urinary tract infection	7	33.33	0	0.00	0.142[a]
Required blood transfusion	3	14.29	3	37.50	0.305[a]
Number of PRC administered (units) mean±SD	1.33	+0.58	2.33	+0.58	0.101[b]
Readmission					
No	26	96.30	16	100.00	1.000[a]
Yes	1	3.70	0	0.00	

Statistical analysis was conducted using various tests, [a]Fisher's exact, [b]Independent t-test
PRC = packed red cells, SD = standard deviation

Table 6. Comparison of pain scores

Variables	Group, mean±SD, 95% CI				P-value
	Pre-ERAS	95% CI of mean	ERAS	95% CI of mean	
Pain score 1 hr	4.85±1.32	4.24-5.47	3.38±1.96	2.57-4.18	0.0052[a]
Pain score 6 hr	5.67±2.04	4.94-6.40	2.75±1.57	1.80-3.70	<0.0001[a]
Pain score 24 hr	4.19±1.27	3.68-4.69	2.75±1.34	2.09-3.41	0.0011[a]
Pain score 48 hr	3.85±1.13	3.40-4.30	2.31±1.19	1.73-2.90	0.0001[a]

[a]Repeated measured ANOVA test
ERAS = Enhanced Recovery After Surgery, CI = confidence interval, SD = standard deviation, hr = hour

Discussion

Urolithiasis is an area of public health concern in Thailand, and Loei province, one of the provinces in the north-eastern region of Thailand, has a relatively high prevalence of the disease.[18] Urolithiasis can lead to pain, infection, renal failure, and even fatalities. Nephrectomy is one of the most effective treatment approaches for management of stone diseases.

Numerous research studies have shown the effectiveness of a multidisciplinary approach in implementing ERAS protocols, resulting in a reduction in the stress response, improved quality of rehabilitation, and increased levels of patient satisfaction. The key to the success of ERAS lies in its structured approach, which comprises three phases: preoperative, intraoperative, and postoperative. These strategies are tailored to individual patients and emphasize various aspects, including a reduction in preoperative fasting, multimodal pain management, early oral intake, and early ambulation.[19,20]

At present, the appropriate perioperative ERAS protocol is typically derived from the framework of research studies conducted by experienced individuals, and subsequently tailored to the unique clinical context. In practice, however, there is a scarcity of research specifically addressing ERAS Nephrectomy in patients with urolithiasis

In this study, laparoscopic nephrectomy was not performed. This was due to the fact that patients with urolithiasis often exhibit fibrotic and inflammatory processes extending to the renal hilum and perirenal adipose tissue. These observations are in line with the findings of the study, where the majority of patients presented with chronic pyelonephritis (80.8%). Consequently, the complexity of performing laparoscopic procedures in the urolithiasis population increases, and complications associated with nephrectomy in urolithiasis patients may occur more frequently compared to those undergoing nephrectomy for renal tumors.[21]

Pain management in nephrectomy offers several modalities, including epidural analgesia, patient-controlled analgesia systems (PCAS), neuraxial techniques, transversus abdominis plane (TAP) blocks, and others. Current research suggests that a multimodal approach is frequently employed.[22] In this study, researchers chose to administer pain management through either epidural nerve block or local anesthesia. The results revealed superior pain control in the ERAS group compared to the Pre-ERAS group, as illustrated in Figure 1.

However, this study could not compare the pain scores recorded between local analgesia and epidural analgesia within the ERAS group, as the sample sizes for such comparisons as these were too small to calculate reliable statistical significance.

The decision to place a retroperitoneal drain after nephrectomy is not yet considered as part of the standard of care and depends on the judgment of the surgeon.[23,24] In this study, insertion of a drain was appropriate in approximately 12.5% of the ERAS group, due to the presence of oozing blood.

In the ERAS group, the absence of the placement of a retroperitoneal drain or the rapid removal of the Foley catheters and retroperitoneal drain (in cases where intraoperative drainage was deemed necessary), in combination with effective pain control, allowed patients in the ERAS group to become ambulant earlier, resulting in a faster return of normal bowel function. Patients in the ERAS group experienced less abdominal distension and had faster recommencement of bowel movement in comparison to the Pre-ERAS group. As a result, patients in the ERAS group had shorter lengths of stay, both total and postoperative, when compared to the Pre-ERAS group. This finding aligns with reports from prior research that applied the ERAS protocol for nephrectomy in various conditions, including renal cell carcinoma and transplantation.[25,26]

In addition, when analyzing complications related to ERAS nephrectomy, there were no statistically significant differences between the two groups. However, it was noted that the incidence of ileus was lower in the ERAS group This observation can be attributed to the ERAS protocol in this study, which involved early ambulation, minimal opioid usage, the utilization of gum chewing[27] and bisacodyl rectal suppository.[28] However, complications associated with epidural analgesia were observed in the ERAS group, including acute urinary retention, hypotension and bradycardia.[22] Nevertheless, the incidence did not show a statistically significant increase in comparison to the pre-ERAS group.

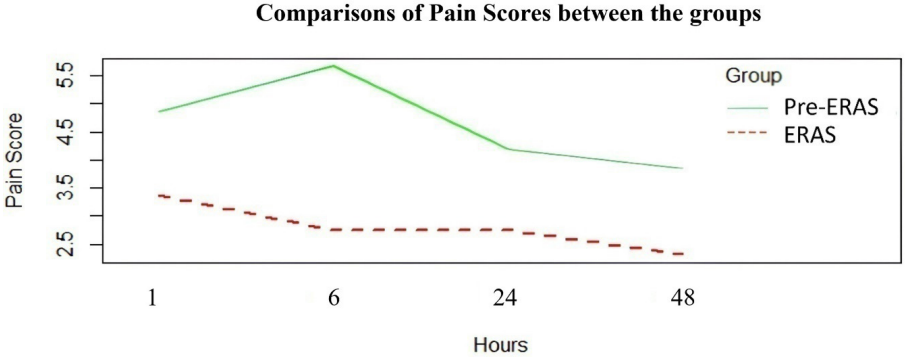

Figure 1. Comparison of Pain Scores at 1, 6, 24, and 48 Hours between Pre-ERAS and ERAS groups.

ERAS implementation did not have a significant impact on renal function, as assessed by pre- and post-operative Cr and GFR. This finding is in alignment with the results of previous research.[25]

In terms of costs, it was observed that there were lower costs associated with the ERAS group in comparison to the Pre-ERAS group, although the cost difference was not statistically significant. This is attributed to the fact that, even though the implementation of ERAS reduces inpatient hospitalization costs, it is associated with additional resource utilization, such as the cost of performing epidural nerve blocks and increased medication expense.

Conclusions

The implementation of ERAS in elective open simple nephrectomy for urolithiasis significantly reduces LOS, and postoperative pain, and results in earlier return of bowel function, faster resumption of normal activities and may result in cost savings without increasing the risk of readmission or complications, and without compromising postoperative renal function.

Conflicts of Interest

The authors declare no conflicts of interest.

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